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Modeling and Computation of Capacitance Matrix for Shielded Vertical Microstrip-Lines using FEM

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Abstract: This paper presents the design analysis of five vertical shielded microstrip lines. The vertical microstrip transition solves the problem of discontinuity between two microstrip lines in different layers of microwave circuit. The main objective of this paper is to compute the capacitance and other relevant parameters like potential distributions of five shielded vertical microstrip line by using finite element technique. the computational and simulation work is carried out with the help of FEM based COMSOL multiphysics software. it has been used in a wide variety of problems like modeling wave guide and transmission lines, cavities etc. To improve the design further, adaptive mesh technique is applied to obtain more accurate result.

Keywords: shielded vertical microstrip, Finite element method, capacitance matrix, Characteristics Impedance.

I. INTRODUCTION

Microstrip lines are most commonly used transmission lines and provide easy connections to active device(transistors or diodes) and allows placement of pre amps or distributed transmitters next to the antenna element[8].In contrast to the so called mirostrip line classical half shielded structure, the full shielded structure referred to as strip line-like microstrip offers the advantage of having the mode velocities independent of strip widths and spacing and as a consequence very good directivity and well defined electrical behaviour. The demand of highly accurate design of microstrips is increasing with the progress of miniaturization and the smart design of equipment [10]. The aim of this paper is to design analysis of vertical shielded microstrip line with negligible thickness in the isotropic and homogeneous medium. The thickness of the strip conductor has been taken negligible because small thickness of transmission line the signals can be easily transmitted at high frequencies with low distortion [3]. The finite element method has previously been applied to the analysis of horizontal, inverted, diamond, V & W shape transmission line with or without dielectric [5,6,7]. However, no attempt has been made to take the negligible thickness of vertical shielded five microstrip lines. This paper shows that our approach is useful for microstrip lines design. The computation of capacitance matrix for shielded vertical microstrips is considered essential in designing of microwave circuits with decoupled passive and active layers.

II. METHOD OF ANALYSIS

The two methods commonly used for analyzing shielded microstrip lines are quasi-static method and full wave methods. While working on higher microwave frequencies, full-wave methods have to be exploited for the analysis. This method is based on the direct solution of Maxwell's equations. The quasi-static methods used in this work are based on assumption that the dominant mode of the wave, which propagates along the transmission line, can be approximated (with good accuracy) by the transversal electromagnetic wave [4]. The field values can then be used to evaluate the potentials and the characteristic impedance [9]. The quasi-static analysis can be performed by modelling the strip lines using computationally efficient Finite Element Method (FEM) [5]. The principle of FEM is based on division of the solution domain into small domains, called finite elements. These domains can be of different sizes such that; in region where anticipation of larger variations in fields, number of elements and their sizes can be changed to obtain higher element densities. The model of shielded vertical microstrip lines are designed under the electrostatics surrounding in COMSOL Multiphysics. It facilitates all steps in the modelling process definite geometry, meshing, specifying physics solving and then visualising results.

The characteristics impedance of lossless transmission line is:

$$Z = 1/c\sqrt{CC_0} \qquad ....(1)$$

Z=Characteristics impedance of line.
C=Capacitance per unit length of line when substrate is replaced with air
$C_{0=}$ Capacitance per unit length of line when substrate is in place
c=speed of light in vacuum

Velocity of propagation is defined in terms of inductance per unit length and capacitance per unit length.

$$v_p = 1\sqrt{LC} \qquad ....(2)$$

Now phase velocity for the air dielectric transmission line, where the velocity must be speed of light, c=2.998×10^8m/sec. By using this value of c in above equation, then equation becomes

$$c= 1\sqrt{LC_0} \quad ....(3)$$

If all material are non magnetic, then

$$L=1/c^2C_0 \quad ....(4)$$

As we know

$$Z_0=\sqrt{L}/\sqrt{C} \quad ....(5)$$

Substituting the value of L in equation (5)

$$Z_0=1/c\sqrt{CC_0} \quad ....(6)$$

For single strip and multiple strip it is easy to compute these parameters using stand alone 2D field solver.2D cross-sectional electrostatic solver is used to compute the capacitance [3].

A. SHIELDED SUSPENDED VERTICAL MICROSTRIP LINES

Figure 1 shows the cross section for vertical suspended stripline with the following parameters:
Dielectric constant, ε_r=8.8
Height of strip, H=10mm
Thickness of strip, t = 0.01mm
Thickness of dielectric material, H_2=20 mm
Height of dielectric material from the ground, H_1=20mm
Height of dielectric material from the top, H_3=90 mm
Height of shield, b=130 mm
Width of shield, a=100 mm

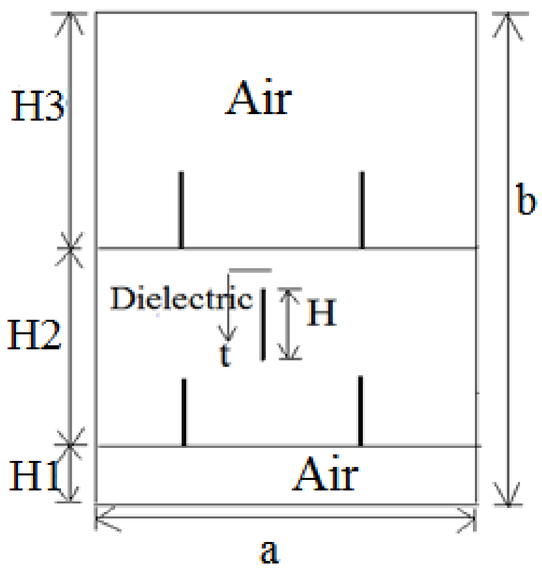

Fig. 1 Cross Section View of Shielded Suspended Vertical Microstrip Lines

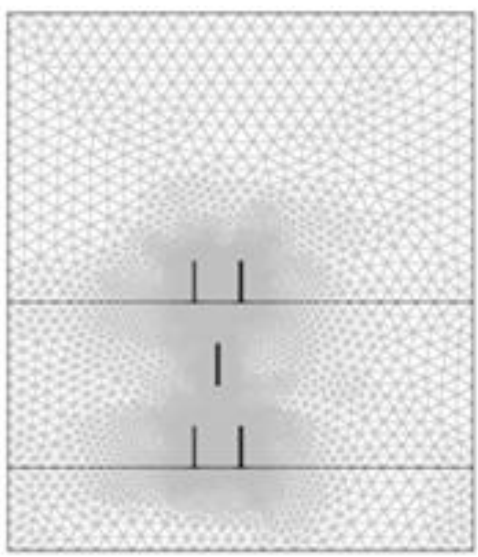

Fig. 2 Refine Mesh of Shielded Microstrip line Dielectric Keeping Centre Strip as Input Port

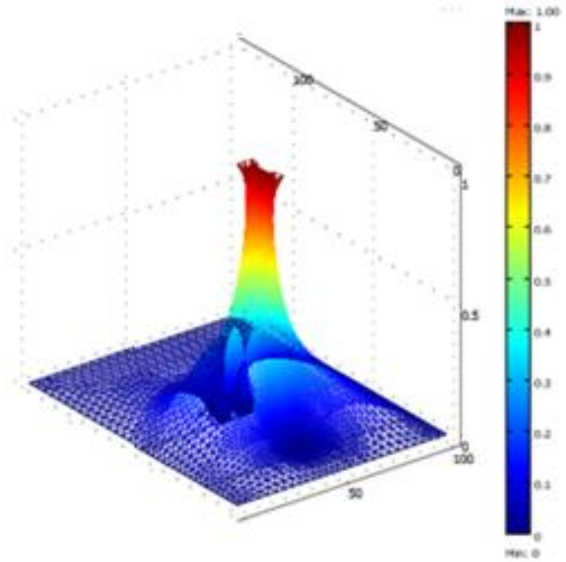

Fig. 3 3D Surface Potential Distribution of Shielded Microstrip Lines Keeping Centre Strip as Input Port

Fig. 4 Stream Line Plot of Shielded Microstrip Lines Keeping Centre Strip as Input Port

The Finite Element based 2D software is used to generate the mesh for the model as shown in Fig.2.In boundary settings inner conductor are act as port while outer conductor act as ground. The mesh consists of 13307 triangular elements and after the refinement of mesh the number of elements increased to 53228.

B. SHIELDED AIR FILLED VERTICAL MICROSTRIP LINES

The shielded vertical microstrip without dielectric is shown in Fig. 5. The dielectric is replaced by air. So, that value of relative permittivity kept 1.The value taken for this geometry is same as with dielectric.

Relative permittivity, $\varepsilon_r = 1$
Conductivity, s=0 S/m
Conducting material:
Relative permittivity, $\varepsilon_r = 1$
Conductivity, $s = 5.8\times 10^7$ S/m

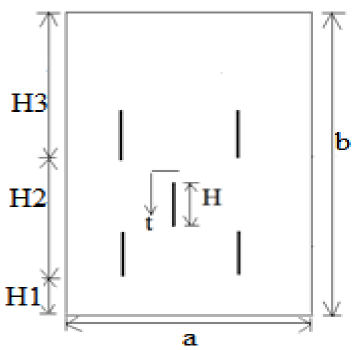

Fig. 5 Cross Section View of Shielded Microstrip without Dielectric keeping Central Strip as Input Port

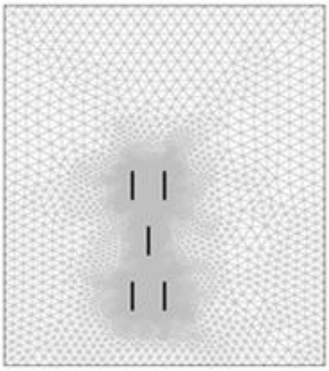

Fig. 6 Refine Mesh of Shielded Microstrip Lines without Dielectric keeping Centre Strip as Input Port

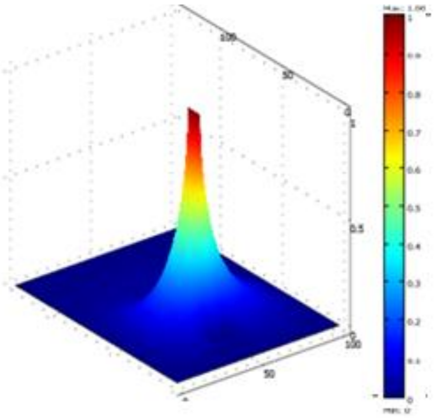

Fig. 7 3D Surface Potential Distribution of Shielded Microstrip Lines without Dielectric using Central Strip as Input Port

Fig. 8 Stream line Plot of Shielded Microstrip Lines without Dielectric keeping Central Strip as Input Port

To improve the design further adaptive mesh technique is applied to both the models with dielectric and without dielectric. Meshing includes automatically refine, coarsen or relocate and adjust the basis to achieve a solution having a specified accuracy in an optimal fashion[1]. After the adaptive refinement, number of mesh points and no. of elements got increased as compared to standard statistics. In Table 1,shows the values of different items of adaptive meshing are compared.

TABLE I. ADAPTIVE MESHING REFINEMENT STATICS OF SHIELDED STRIP LINE

Items	**Without dielectric**	**With dielectric**
No of degree of freedom	969085	106575
Total mesh points	242303	26674
Total elements	484480	53228
Triangular elements	484480	53228
Vertex elements	1444	1806

III. SIMULATION RESULTS

The simulation is done to compute the capacitance matrix and potential distribution of the model. The potential values are used to evaluate the characteristics of the microstrip lines. The Fig.10 shows the surface potential distribution within shielded vertical microstrip lines for both cases.

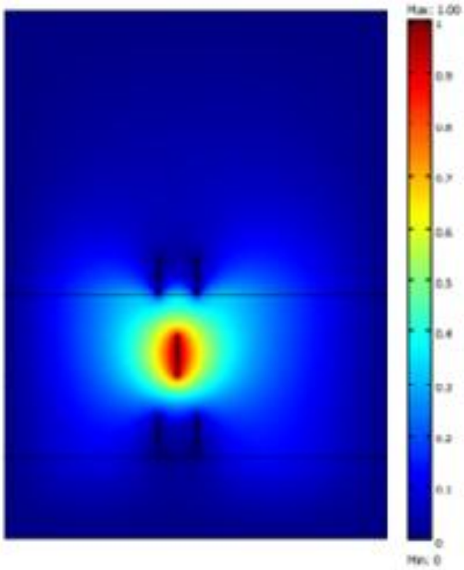

Fig. 9 2D Surface Potential Distribution of Shielded Microstrip Lines With Dielectric

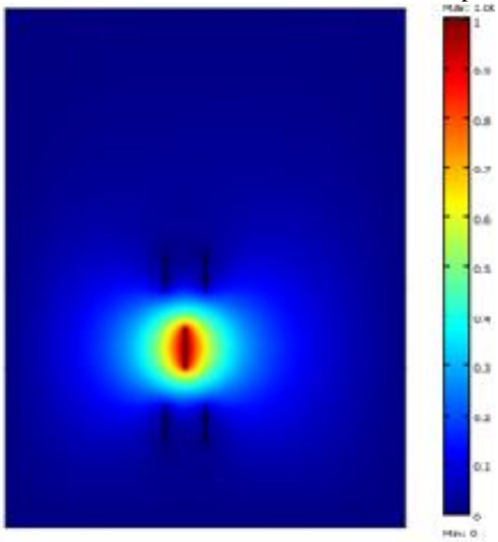

Fig. 10 2D Surface Potential Distribution of Shielded Microstrip Lines Without Dielectric

The value of capacitance varies when the dielectric placed in vertical shielded microstrip lines. The capacitance for both the models have been computed with coarse and fine mesh refinement as shown in table II. The result of capacitance matrices, are useful for the analysis of crosstalk between high speed signal traces on the printed circuit board [5].

TABLE II. CAPACITANCE MATRIX (IN F) FOR FIVE TRANSMISSION LINES WITH AND WITHOUT DIELECTRIC

Capacitance	**With Dielectric**	**Without dielectric**
C_{13}	-4.40×10^{-11}	-4.48×10^{-12}
C_{23}	-2.29×10^{-11}	-4.61×10^{-12}
C_{33}	1.94×10^{-10}	2.46×10^{-11}
C_{43}	-4.56×10^{-10}	-6.86×10^{-12}
C_{53}	-2.33×10^{-11}	-2.36×10^{-12}

The potential distribution along the line that goes from(x, y)=(0,0)to(x, y)=(100,130) portrayed in Fig. 11 & 12. It can be observed from both the figs, that the peak value of electric potential is increased as the dielectric placed in the outer conductor.

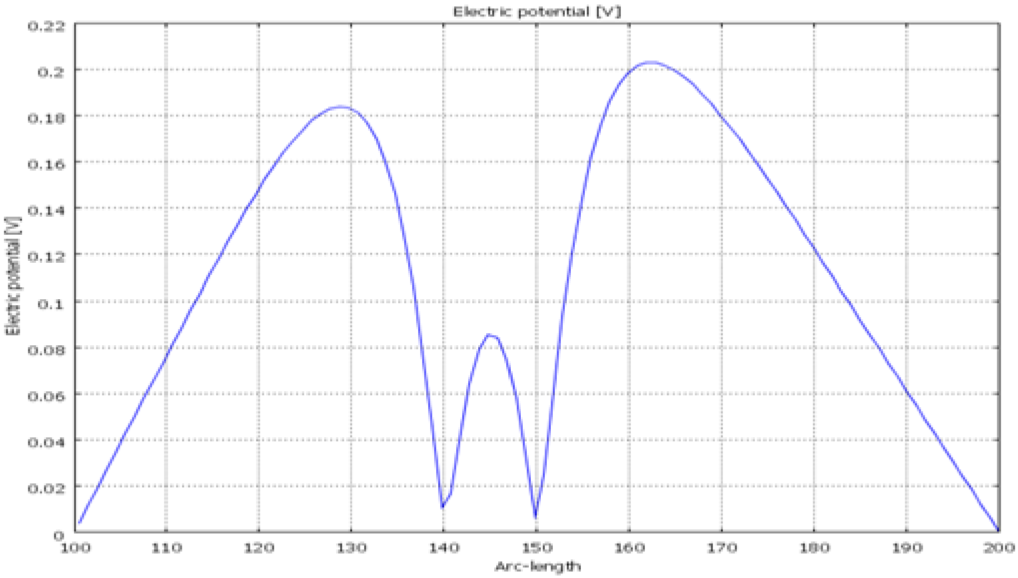

Fig. 11 Potential Distribution of Shielded Microstrip lines with Dielectric Keeping Centre Strip as Input Port

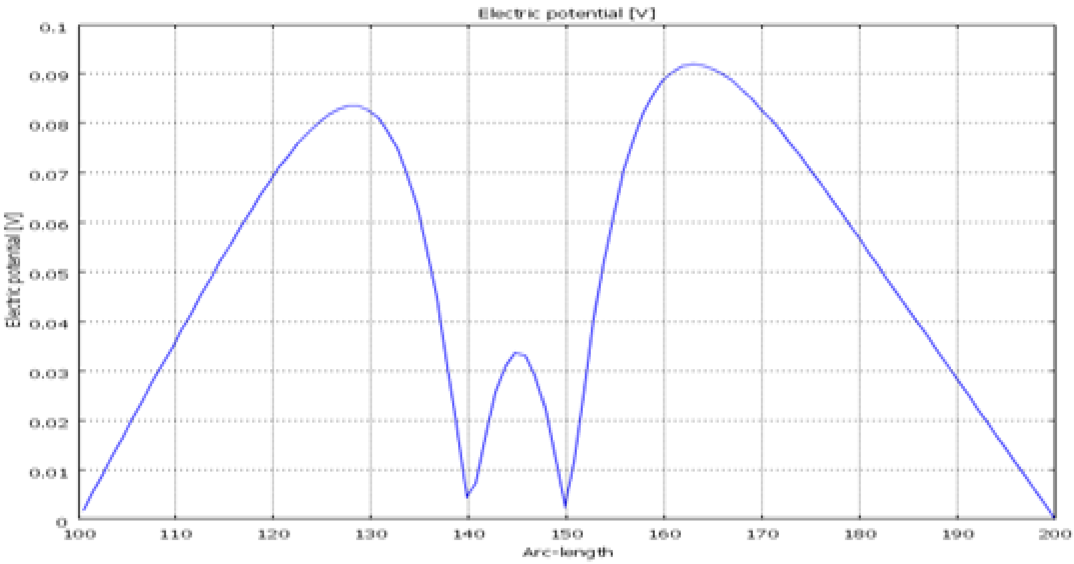

Fig. 12 Potential Distribution of Shielded Microstrip Lines without Dielectric Keeping Centre Strip as Input Port

IV. CONCLUSIONS

Due to complexity of electromagnetic modeling, researchers and scientists always look for development of accurate and fast methods to solve the problem of microstrip transition for multilayer microwave circuits and printed circuit board (PCB). This paper demonstrate the modeling of vertical microstrip lines with its design parameters like capacitance matrix and potential distribution. Our approach is useful to solve the problem of discontinuity at the different layers of microwave circuit. The FEM based comsol multiphysics software is used. The results are further improved by applying the adaptive mesh refinement technique on the models. The same analysis can be further applied to investigate the design parameters for different configuration transmission lines.

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REFERENCES

[1] R. Kaur, Satvir Singh Sidhu, M.S. Manna, ‟2D FEM Analysis of microstrip Circular Patch Array Antenna,” Proc. of International Conference on Computer Science and Engineering (ICCSE), pp. 1-6, 2012

[2] Mirjana T. Peric, Sasa S. Ilic, Slavolub R. Aleksic , Nebojsa B. Raicevic, ‟ Analysis of 2D Symmetrically Coupled Vertical Microstrip between Two Infinite Grounded Planes using HBEM”, Proc. of International conference on Applied and Theoretical Electricity (ICATE), pp. 1-5, 2012.

[3] P. Kakria, A. Marwaha, M. S. Manna, “Optimized Design of Shielded Microstrip Lines Using Adaptive Finite Element Method”, Excerpt from the proceedings of Comsol Confrerence, Bangalore, India 2011.

[4] Pan S., "Equivalent Transmission model for vias Connected to Stripline for Multi Layer PCB", in Compliance Magazines-The Compliances Information Resource, For Electric Engineers, 2010.

[5] S. M. Musa & M. N. O. Sadiku, ‘‘ Fast Computation of Capacitance Matrix and Potential Distribution for multiconductor in Non - Homogeneous Multilayered Dielectric Media", Excerpt from the proceedings of COMSOL Conference, Boston, USA 2009.

[6] S.M Musa & M.N.O. Sadiku, ‘‘ Modeling of Shielded, Suspended & Inverted Microstrip Line, ’’ IEEE Transactions, pp. 309-313, 2008.

[7] S.M Musa & M.N.O. Sadiku, ‘‘ Modeling & Simulation of Shielded Microstrip Lines,’’ Technology Interface/Fall, pp. 1-22, 2007.

[8] A .Milligan Thomas, *Modern Antenna Design*, 2nd Edition, John-Wiley and Sons Publications, 2005.

[9] Dorel Homentcovschi,Anton Manolescu, Anca Manuela Manolescu & Liviu Kriendler, ‘‘An Analytical Solution for the coupled Stripline like Microstrip Line problem, ’’ IEEE Transactions on Microwave Theory and Techniques, Vol. 36, No.6, pp. 1002-1007, 1988.

[10] Zoriac Pantic & Raj Mitra, ‘‘Quasi TEM Analysis of Microwave Transmission Lines by Finite Element Method , ’’IEEE Transaction Microwave Theory & Techniques, Vol. MTT - 34, No.11, pp. 1096-1103, 1986.

